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THE INSPECTION OF MECHANICAL INSULATION SYSTEMS
More Important Today than Ever Before

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INTRODUCTION

There are inspection requirements in many construction disciplines, including electrical, welding, coating, plumbing, and the list goes on, but not for mechanical insulation. The benefits of properly designed, installed and maintained mechanical insulation systems are well-documented. However, these benefits can be greatly reduced with the potential of significant consequences when there is improper design, application, or maintenance, the results of which can be extensive and easily exceed the initial cost of the insulation system. The cost of insulation inspection is certainly minimal compared to the potential long-term cost of minimizing or identifying areas of concern or risk. The need for a certified mechanical insulation inspection program is long overdue.

Mechanical insulation systems are defined as the materials used to insulate piping, equipment, vessels, ducts, and all types of mechanical items. For years, I have referred to mechanical insulation as the Rodney Dangerfield technology of the industrial and commercial industries—"we get no respect."

Why are those characterizations valid and why is the inspection of mechanical insulation more important today than ever before? That is the focus of this article.

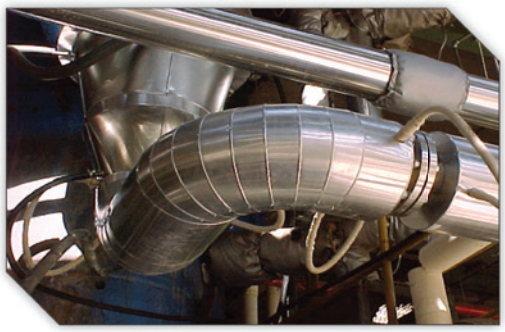
WHY INSULATE?

Understanding why insulation is being used is important to the insulation inspection process. Mechanical insulation is primarily used to limit heat gain or loss from surfaces operating at temperatures from cryogenic temperatures to +1,200 F. The theory of heat transfer is the core topic behind each insulation design objective.

The "design objectives" for mechanical insulation systems are: condensation control; energy conservation; fire safety; freeze protection; personnel protection and/or comfort; process control; and noise or acoustical control.

The "design objectives" are the primary purposes for which insulation systems are designed. But there are also "design considerations," which are other conditions that may need to be considered in the ultimate design and selection of a mechanical insulation system. Design consideration examples are: abuse resistance; corrosion under insulation (CUI); indoor air quality; maintainability; regulatory considerations; service and location; and service life.

For mechanical engineers and other design professionals, determining a proper insulation system for the respective application and thus to craft the appropriate and complete specification should not be a complex formula. However, that is often not the case.



Mechanical insulation with aluminum protective covering and the use of flexible removable/ reusable insulation covers.

Mechanical insulation with laminate protective covering.

Design Objectives	Design Considerations
Condensation Control	Abuse Resistance
Energy Conservation	Corrosion under Insulation (CUI)
Fire Safety	Indoor Air Quality
Freeze Protection	Maintainability
Personnel Protection and/or Comfort	Regulatory Considerations
Process Control	Service and Location
Noise Control	Service Life

INDUSTRY REALITIES

For the purposes of this article, the mechanical insulation industry encompasses insulation system component manufacturers and other parts of the supply chain, including facility owners, engineering/design firms, and all contractors in the installation chain.

Lack of Curriculum and Knowledge

Insulation is taken for granted in many applications. Mechanical insulation is not a major topic in many engineering curriculums,

and it's not considered a popular topic of discussion in the design or facility owner communities. However, understanding the need and importance of mechanical insulation and the basic need for an inspection program is where the value of inspection begins to become evident.

Dwindling Knowledge Base

Whether created by right-sizing, attrition, consolidation, or other similar occurrences there is consensus that the mechanical insulation knowledge base within the engineering and facility owner communities—and directly within the industry itself—is slowly dwindling to that of only basic knowledge with little actual experience. During presentations, I like to conduct an informal survey of mechanical engineers in the audience and ask how many hours they spent on thermal insulation while obtaining their degree. No one has ever reported spending more than 30 minutes.

Less Time Spent on Monitoring

There are fewer individuals within engineering and design firms that are focused on mechanical insulation and they are spending less time monitoring project site practices in the field. In many cases, they never hear about insulation again unless a problem is identified and then it may be too late.

More Options and Alternatives Available

In some cases, insulation systems are getting more complex with more options and alternatives than ever before. In other words, the complexity of the insulation systems combined with the dwindling knowledge is problematic.

Today, by my count, there are 11 basic types of Cellular insulation, 6 Fibrous, 5 Granular, 2 Reflective, and multiple variations of Hybrid Systems. Many of these materials are acceptable for use in common temperature ranges. Combine that with the understanding that basically all materials require some degree of fabrication, and you quickly see the potential degree of complexity. It is not as simple as it seems. Seldom do you just open a box of insulation from a manufacturer and install it.

Add in all the optional closure systems, vapor retarders, protective jacketing systems, securement methods, and there are easily over 100 different system variations—not counting the differences between manufacturers or the complexities of multiple-layer systems.

Qualified Worker Shortage

The shortage of experienced, qualified workers continues to be a challenge. The demand for increased productivity, combined with the qualified worker shortage, could be a recipe for significant insulation problems. This is especially true for technical insulation systems used for below-ambient operating temperature service or systems where corrosion under insulation is possible.

Compressed Construction Schedules

Construction schedules continue to be compressed to save costs and/or begin operations sooner, which can result in pushing critical details downstream. That is one of the reasons why some projects are being started and requests for insulation quotations and contracts are being awarded with incomplete drawings.

Mechanical insulation is typically one of the last activities on a project, thus subject to schedule pressures due to previous schedule difficulties. In other words, the end is in sight, so help make up some lost time. Unfortunately, in a scenario where alternatives are agreed to in order to improve schedule concerns or make up budget overruns, mistakes are likely to occur. That is the process that is often referred to as "value engineering," which in many cases means hurry up and reduce costs.

Modularization

Modularization is becoming increasingly popular as a means to reduce costs and address schedule completion targets. Preassembled modules coming from outside the United States could potentially use different insulation systems and/or insulation thicknesses that are traditionally not used in the United States, which could be problematic for many reasons.

Even when modules are built in the United States, the reality is that installed insulation does not travel well, and damage is often incurred during transportation, specifically during the handling and tie-in process.

The other reality with modularization is that many times modules are completed, transported, and stored for months before being tied into the overall system and becoming operational. Considering that damaged insulation may be subject to moisture intrusion, and that the damaged insulation may or may not be replaced, and inspection of insulation for moisture occurrence is a rarity, the development of CUI may not be just a possibility but rather a certainty. In addition, the performance of the insulation system may not satisfy design expectations.

While modularization may be a cost-saving initiative and a method to meet schedule deadlines, its impact on mechanical insulation could be a concern from a total cost and quality perspective.

Fewer Companies Specializing in Mechanical Insulation

There are fewer companies that specialize only in mechanical insulation as the role of multiservice companies continues to expand. While that business platform has been successful on multiple fronts, there is the potential of reduced focus on mechanical insulation. There can be a fundamental difference in an insulation company doing other work to complement their product or service lines, versus a company offering a multitude of services with insulation being one of those. This is not always true, but the internal company knowledge and focus on mechanical insulation remains important to achieve a successful installation.

Enhancing the Value of QA/QC Programs

Many companies that have a QA/QC program have individuals administering the program that know the QA/QC process, but not necessarily for mechanical insulation. A focused mechanical insulation inspection program will enhance the value of

current QA/QC programs or is a good starting point to begin one. An inspection program, which some would say is like a QA/QC program, will raise the bar over time, which will impact all aspects of the mechanical insulation process.

Commissioning Process

Project commissioning is the process of ensuring that all systems and components of a building, or manufacturing or industrial plant, are designed, installed, tested, operated, and maintained according to the operational requirements of the owner or end user. In most cases the inspection of mechanical insulation is not included in the commissioning inspection process. Yet, underperformance of the insulation system could impact the operational performance of the system or process.

Consequences of a Bad Specification

Mechanical insulation contractors and others continue to complain about incomplete, outdated, or irrelevant mechanical insulation specifications (i.e., "bad specifications"). You would be surprised as to the number of "cut and pasted," outdated, or incomplete mechanical specifications that are encountered on a routine basis.

Incomplete and outdated information in specifications, coupled with multiple potential conflicting references (guidelines, codes, standards, etc.), can create inconsistencies. It is also possible that conflicts can exist between drawings and specifications, and other documents that combine to make a mechanical insulation or construction contract.

There are multiple consequences, in addition to general customer dissatisfaction, resulting from a bad specification for all involved, especially the facility owner.

Specification Compliance

It's impossible to have this discussion without mentioning the age-old concern that some contractors take installation shortcuts and do not comply with specifications. That may happen, but when you consider the issues of specification clarity, the worker shortage, construction schedule compression, and lack of inspections, you must ask, is a contractor taking a shortcut or is the occurrence simply a combination of many factors?

Regardless of where you are in the decision or installation chain, inspection and specification compliance verification could support an effective defense for any potential liability related issues.

Consequences of Improper Installation or Regular Maintenance

Some facility owners are focused on initial capital expenditures and not the long-term risks of improper design, installation, or failure to ensure timely and proper maintenance of mechanical insulation systems. These approaches can lead to consequences such as energy loss; however, the larger consequences like personnel safety, corrosion under insulation, mold generation, etc., are often overlooked until a problem develops.

Corrosion under insulation (CUI)

The CUI discussion or debate is not new and will likely continue.

Insulation does not cause corrosion. The temperature range where corrosion can occur may vary depending upon who you ask, but it still takes 3 items to create CUI:

- temperature;
- prolonged exposure to moisture—water or from the insulation in the presence of water; and
- water and contaminants, which can come from the atmosphere and/or the insulation

Many believe that water or water vapor will eventually find its way into an insulation system. It's not a matter of if, but when. If that assumption is correct and water remains within the insulation and in contact with the equipment, there is high potential for the development of corrosion. Contaminated water reaching the substrate is not the problem—the retention of water or continual exposure to water at the substrate is the problem.

CUI development is potentially higher on systems where temperatures cycle, are down or sit idle for an extended period of time before being put in service, and other similar scenarios.

The CUI issue will continue until a total insulation system approach is taken, including proper coating of the substrate, proper attention focused on insulation system design, installation, and timely and effective proactive maintenance programs

Corrosion under insulation

are implemented and maintained.

Inspection of mechanical insulation plays a vital role in helping to identify potential areas where CUI can occur which may necessitate repair or replacement before it becomes a major problem leading to the potential of significant financial loss, personal injury, or even loss of life.

These industry realities, and there are more, certainly make the case as to the need and importance of specifying and

implementing a mechanical insulation inspection program on new construction projects and existing facilities.

WHY NOW AND WHO REQUESTED A MECHANICAL INSULATION INSPECTION PROGRAM BE DEVELOPED?

The concept and need were first presented to the National Insulation Association (NIA) in January 2017 by an Advisory Committee consisting of engineering and facility owner representatives. Program development began in November 2017, and over the next 14 months, the program took shape with a pilot class in December 2018 consisting of invited participants from all industry segments (facility owners, engineering firms, insulation manufacturers, and insulation contractors). NIA's inaugural Thermal Insulation Inspector Certification™ course was held in May 2019.

THE INSPECTION OF MECHANICAL INSULATION

The message from the industry was loud and clear, but developing and implementing a certified mechanical insulation program was not as simple as it sounds. Many think the installation of mechanical insulation is a simple process, but realize it is not after examining all that goes into making a successful insulation system. Underestimating the complexities and components of mechanical insulation systems may be one of the primary drivers for the inspection of mechanical insulation systems.

Considering the industry realities and that many of the subjects are intertwined, the knowledge required to become an effective mechanical insulation inspector came into focus. Having inspection credentials in another discipline, such as coatings, does not qualify someone to be a mechanical insulation inspector.

The following is an overview (not an all-inclusive list) of the topics and areas a mechanical insulation inspector would need to have a thorough understanding of:

1. The principles and fundamentals of mechanical insulation science and technology
2. The importance of inspecting mechanical insulation systems
3. The importance of "Why Insulate" to the inspection process
4. The wide variety of insulation materials and securement methods for below and above ambient operating systems
5. The different types of protective coverings and why they are important
6. Insulation terms used to define various insulation forms
7. How Safety Data Sheets (SDSs) relate to the inspection of mechanical Insulation and the importance of safety program protocol in the inspection process
8. How to read a specification and differentiate between codes, standards, regulations, specifications, and guidelines and how they may or may not be intertwined in defining the basis of inspection
9. How to identify and define the controlling documents which include the basis for inspection
10. The importance of unbiased Inspection
11. How to review specifications and determine if alternate materials are comparable to the specified materials
12. The importance and difficulties in determining installation details
13. The inspection process differences between new construction and maintenance
14. How to apply insulation knowledge and common sense in the inspection process
15. How to identify some of the common signs that indicate a potential issue and address them during the insulation inspection process

Example of cutting into an insulation system to inspect for corrosion under insulation

16. The difference between non-destructive and destructive testing
17. Mechanical inspection tools, techniques and the reporting process, including the use of hold points and witness points in the inspection process
18. While inspection of any discipline requires an inspection plan and schedule, and know why the inspection of mechanical insulation is somewhat different
19. How weather events can have a pronounced effect on the success or failure of insulation systems

Example of mechanical abuse (probably foot traffic) damaging the insulation system opening joints for moisture intrusion

Example of improper insulation joints and installation of joint sealer

20. The discussion surrounding CUI from an insulation inspector perspective versus a coating or paint inspector. That may sound like a minor difference, but it is not.

'Simple' is something that is easy to understand or do and presents little or no difficulty. 'Complex' is defined as consisting of many different and connected parts. While some aspects of the inspection of mechanical insulation may be deemed simple, the overall inspection process represents a complex equation. That is the basis of the extensive listing of knowledge requirements for an effective mechanical insulation inspection program.

COST OF INSPECTION

While cost is important—as a former CEO of several companies—I prefer to address the return on investment (ROI) for the mechanical insulation inspection process. Determining value and/or ROI is dependent on your company's point of view. Obviously, a facility owner's perspective of committing large sums of capital dollars to building, expanding, or improving a facility would be different from an insulation contractor who is one of the last crafts on a project that is focused on project profitability.

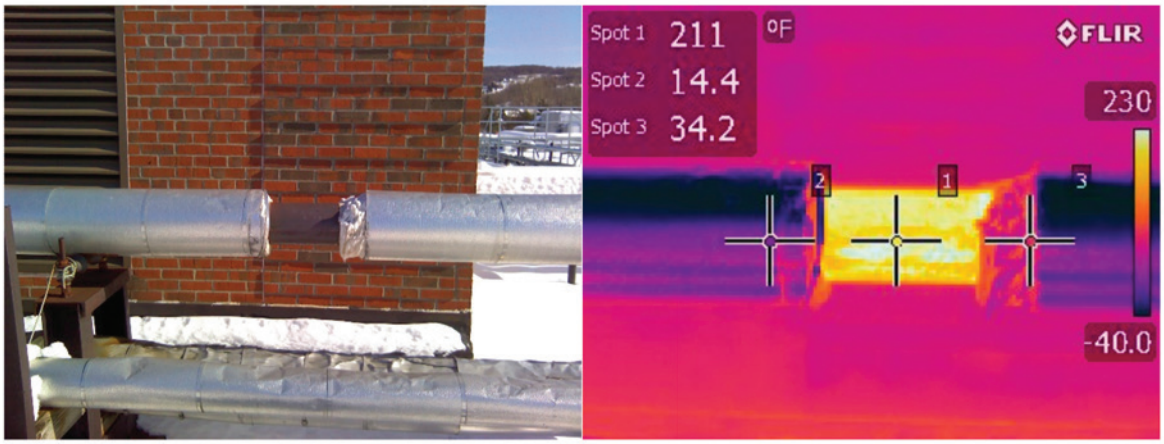
Operating a facility also generates a different perspective. Unfortunately, maintenance cost is typically considered just that, cost that negatively impacts the bottom line. Should some maintenance cost be viewed from an ROI perspective, especially if it is potentially guarding against or reducing the need for future capital dollars or much larger maintenance budgets? Those discussions are left to the financial teams and may or may not include operational personnel in the decision process, which may be part of the problem.

Like in many situations it often comes down to a money issue. All the components that go into many financial decisions are complex, but there is no doubt that those decisions impact many groups.

Companies are continually striving to reduce costs and in many cases are reducing staff size and relying on non-traditional

Example of using non-destructive inspector ports too late: Moisture had gotten into the system creating a host of problems—from mold development and separation of the insulation joints due to increased weight among other issues.

Example of unacceptable workmanship while trying to insulate an elbow



Example of missing insulation and with the use of infrared technology, clearly demonstrating the heat loss which equates to dollars. Note the foot traffic damage on the lower insulated piping.

methods and technology. Unfortunately, simple cost reduction analysis often puts inspections and maintenance in jeopardy. I can't speak for other disciplines but in the case of mechanical insulation, that approach can lead to equipment failure and subpar performance will result in cost increases that will exceed any short-term perceived cost savings. For mechanical insulation, if you believe that short-term savings due to poor or non-existent practices will not negatively impact future costs, in most cases that is simply not realistic. History has proven that to be true.

Mechanical insulation and the inspection of mechanical insulation should be considered an investment, no matter how the cost is reflected on the financial statement. They should yield an attractive ROI while reducing future costs and the need for Capex funds due to damage to and/or failure of equipment from issues related to poor practices.

In the overall cost of new construction and facility maintenance, mechanical insulation is a very small piece of the puzzle. Its impact is taken for granted during the design phase, not traditionally inspected during the construction phase, and not focused upon in the maintenance phase. That equation will ultimately yield negative results for the facility owner.

Effective inspection practices seems to be an easy and less expensive means to change that historical practice while helping to identify areas of concern that may have the potential for an even greater expense. Even to a financial rookie, that appears to be an attractive formula.

CONCLUSION

The inspection of mechanical insulation systems is more important today than ever. If you consider the industry realities, that industry is requesting certified mechanical insulation inspectors and the financial benefits of that inspection the conclusion is – the use of properly trained and certified mechanical insulation inspectors should be included in all new construction projects and be an integral part of facility maintenance programs.

The benefits of inspection will vary depending upon company's function (i.e., facility owner, design or engineering firm, insulation contractor, inspection firm, mechanical or general contractor, etc.). Regardless, the benefits are real, as well as the risk of not implementing a mechanical insulation inspection program.

Having a mechanical insulation inspection program and certified inspectors will not resolve all concerns, but it does provide a way for engineering firms, facility owners, and others to verify that they are receiving what they expect and to identify potential areas of concern during initial installation or in ongoing operations. ■

For more information on this subject or the author, please email us at inquiries@inspectioneering.com.

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Ron King is a Past President of NIA, the World Insulation and Acoustic Congress, and the Southwest Insulation Contractors Association. He was awarded the NIA's President's Award in 1986 and again in 2001. He is a 50-year veteran of the commercial and industrial insulation industry, during which time he held executive management positions as an accessory manufacturer and specialty insulation contractor. He retired (2004) as the Chairman, CEO, and President of a large national insulation distributor/fabricator. He currently serves as a consultant to the NIA on a variety of educational, outreach, and governmental initiatives.